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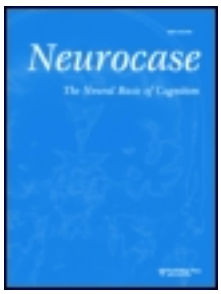

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Case report: A prototypical experience of 'poltergeist' activity, conspicuous quantitative electroencephalographic patterns, and sLORETA profiles - suggestions for intervention

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Case report: A prototypical experience of 'poltergeist' activity, conspicuous quantitative electroencephalographic patterns, and sLORETA profiles – suggestions for intervention

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People who report objects moving in their presence, unusual sounds, glows around other people, and multiple sensed presences but do not meet the criteria for psychiatric disorders have been shown to exhibit electrical anomalies over the right temporal lobes. This article reports the striking quantitative electroencephalography, sLORETA results, and experimental elicitation of similar subjective experiences in a middle-aged woman who has been distressed by these classic phenomena that began after a head injury. She exhibited a chronic electrical anomaly over the right temporoinsular region. The rotation of a small pinwheel near her while she 'concentrated' upon it was associated with increased coherence between the left and right temporal lobes and concurrent activation of the left prefrontal region. The occurrence of the unusual phenomena and marked 'sadness' was associated with increased geomagnetic activity; she reported a similar mood when these variations were simulated experimentally. Our quantitative measurements suggest people displaying these experiences and possible anomalous energies can be viewed clinically and potentially treated.

Keywords: Quantitative electroencephalography; sLORETA; Poltergeist-like phenomena; Geomagnetic sensitivity; Right temporal lobe; Closed head injury.

Reports of anomalous sounds, movements of proximal objects, and electromagnetic transients in the vicinity of individuals who are displaying psychological or physiological distress have been reported for centuries by both the experient and witnesses (Owen, 1964). Although there is evidence that some cases may involve measurable displays of energies and forces that are not easily explained (Roll, 1986, 2003) by individuals displaying dissociative disorders or fraudulence, we think a greater priority is the clinical responsibility to appropriately treat these individuals. They or members of their families are often distressed by the phenomena because of their pejorative classification or causal attribution by the culture's tradition to such things as 'demons' and the 'spirits' of deceased individuals. These associations may actually exacerbate the psychological and sometimes psychiatric distress.

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Our approach is that measurement of the neuroelectrical correlates of individuals who report these phenomena could facilitate development of strategies for intervention. Although such measurements may also someday elucidate the potentially important theoretical bases for their occurrence, more importantly they could reveal clinical options for treatment. The present case involves a middle-aged woman who, following a closed head injury during a motor vehicle incident, began to report anomalous experiences that were described by others, including health professionals, as 'poltergeist-like'. Her profile and our quantitative electroencephalographic (QEEG) measurements were congruent with previous reports to the extent her case was considered representative for these phenomena.

Roll and Persinger (2001) reported that individuals around whom anomalous energies are displayed have either been diagnosed or are suspected to display complex partial epilepsy with a temporal (usually right) lobe focus. The forces or energies (force over distance) associated with the odd sounds, object movements, and electrical disturbances (anomalies in electronics) are well within the range of magnitude (i.e., in the order of 10–20 Newtons and 100–200 J/s) displayed by the human body during normal physical movement. Dielectric materials (glass, plastics) are reported to be displaced more often than conductors (which become warm) for distances between a few centimeters to several meters as a function of the inverse square of the distance and of the exponential decay function from the person. The phenomena cease when the person sleeps (Roll, 1986; Roll, Burdick, & Joines, 1973a, 1973b). The frequency of occurrence may vary with the level of 'distress' reported by the person.

Analyses of historical cases (Gearhart & Persinger, 1986) indicated the onset of these phenomena were strongly correlated with increased global geomagnetic activity within the same order of magnitude known to be associated with increases in epileptic seizures in humans and rats (Rajaram & Mitra, 1981; Persinger, O'Donovan, McKay, & Koren, 2005). That such paroxysmal activity in electrically labile brains can be evoked by these weak magnetic fields has been shown experimentally by simulating the intensity and pattern of geomagnetic activity in the laboratory (Michon & Persinger, 1997). The development of recent QEEG technology has revealed powerful associations between shifts in power spectra within the theta and gamma band, particularly over the right hemisphere, during increased geomagnetic activity (Babayev & Allahverdiyeva, 2007; Mulligan, Hunter, & Persinger, 2010) and simulations of this activity (Mulligan & Persinger, 2011).

PATIENT AND METHODS

The patient, Ms. S, was a middle-aged married woman with no children. She had received an undergraduate university degree about 20 years before the assessment and was trained as a commercial artist. At the time of the assessment she was pursuing her doctorate in a physical science. About 17 years before the current measurements she had been involved in a serious motor vehicle collision that resulted in a coma for approximately 2 days. She was diagnosed with moderately severe traumatic brain injury (TBI). Most of the injuries, including those to the skull, were along the right side of her body. At the time of the TBI she was serving in the military. She was also an experienced drummer.

Following the TBI, the relationship with her first husband deteriorated because he insisted she was not the same person. This 'change in personality' is a frequent report by spouses of individuals who have sustained TBIs. According to her reports one night he tried to kill her. The anomalous phenomena began that night and have been intermittent since that time. Their intensity and frequency have increased during the last 2–3 years. The anomalous phenomena include mechanical, electronic, and visual effects. She reports experiences of sounds, perceived as 'taps' that she estimates to be between 3 and 4 Hz with sound pressure equivalents between 40 and 60 db. Occasionally there may be a single louder sound. The durations of clusters are often between 3 and 10 seconds with intervening periods of 4–8 or 16–24 seconds. The clusters are usually localized along her left side.

The patient experiences luminous 'discharges' from her left hand. Small spatial displacements of objects as well as disruptions in electronic equipment (particularly failed light bulbs) near her were also reported. The incidence rates of the phenomena increase when she is 'upset' with her second husband. This husband and her friends have reported hearing these sounds. She reports lights of various colors and glows around individuals according to their perceived mood and 'personality'.

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Ms. S. reported she feels overwhelmed by a deep sadness after the occurrence of the phenomena and cries, even if nothing 'bad happens'. Since the beginning of these phenomena she hears voices of multiple 'imaginary' friends who she has named; the two major ones are identified as male. They presumably help her minimize the distress of the experiences. Her current medical history is unremarkable except for above normal ($z > 3.00$) red blood cell distribution width (RCDW) that has been present for the last 4 years and began approximately at the time of the exacerbation of the phenomena. Although she has been examined for anemia, and hemoglobin levels have been occasionally below normal (or borderline), only the RCDW measures have been consistently abnormal.

One of the strategies she learned to reduce her stress and the incidence of the 'uncontrolled' phenomena has been to concentrate upon a pinwheel, a small piece of paper balanced on a needle-sharp point. She reported that when she is 'in the state', the paper rotates quickly. When she listens to loud music through headphones, the rotation does not occur. Soft music does not interfere with the observed rotations while intermediate loudness slows the rotation.

The patient travelled to the laboratory and resided at a local hotel the night before the measurements began. For two successive days QEEG measurements were taken (about a dozen different samples with a total of about 4 hours) while she sat within various places inside and out of an acoustic chamber which was also a Faraday cage (Booth, Koren, & Persinger, 2005). When she was inside the closed acoustic chamber, communication occurred by lapel microphone.

For the QEEG we used a portable Mitsar 201 system amplifier which sampled at 500 Hz within an input range of ± 500 μV and 16 bit analogue to digital conversion. The electrode cap (Electro-Cap International) contained 19 AgCl electrodes using the 10–20 international standard method of electrode placement with ear referencing (monopolar recordings). Impedance for all electrodes was maintained at less than 10 kOhms. WINEEG v2.82 was utilized for data collection, artifact removal, and spectral analyses.

Source localization was completed using sLORETA (standardized low resolution electromagnetic tomography) software on artifact-corrected data using the 3-Spherical Shell Head Model registered to Talirach Coordinates (Jurcak, Tsuzuki, & Dani, 2007; Pascal-Marqui, 2002). sLORETA has cross-modal validation with respect to Brodmann area mapping with as few as 19 channels (Mulert et al., 2004; Winterer et al., 2001). In addition to sLORETA's ability to localize sources with minimal error in the presence of noise, it produces results comparable to other source localization algorithms (Wagner, Fuchs, & Kastner, 2004). All coherence measures were completed by EEG Lab software (Delorme & Makeig, 2004). Microstates were extracted from eye blink artifacts-free EEG records to produce topographies based upon the 19 sensor positions (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2) and analyzed according to Koenig et al. (2002).

Microstates, whose durations are in the range of a percept between 80 and 120 ms, are defined as periods of quasistable topographical maps of the cumulative scalp electrical field disregarding polarity (Lehmann, Pascal-Marqui, Strik, & Koenig, 2010). Isopotential lines reveal four major stable maps that accommodate about three-quarters of the variance. To discern potential changes in steady-state (DC) fields over the entire body, which have been shown to be sensitive to changes in the physical environment and to states of consciousness (Burr, 1972; Ravitz, 1959), microvoltages were measured between the back of the neck and left hand by a Keithley 155 Null Detector Microvoltmeter. Typical measurements from our laboratory have ranged between 10 and 15 mV.

To measure any anomalous photon emissions from the head of Ms. S during her attempts to move or focus upon objects, a Model 15 Photometer from SRI (Pacific Photometric Instruments) with a PMT housing (BCA IP21) for a RCA electron tube (no filters) was used while she sat in the dark. The PMT was placed 15 cm from the right side of her head. The right side of the head was selected for measurement because it displays significantly more variation (compared to the left) coupled to cognitive process such as visual imagery (Dotta, Buckner, Lafrenie, & Persinger, 2011). The calibrated measurements (1 unit $= 5\times10^{-11}$ W/m^2, about $500\times$ background levels of cosmic ray incidence which is approximately 10^{-13} W/m^2) were recorded once per sec to a IBM ThinkPad laptop (Windows 95) during periods when she rested and engaged in various efforts to turn the wheel or 'send energy'. At the same time QEEG measurements were completed and analyzed to discern if there were any particular microstates associated with discrete changes in photon density.

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During the first day, she attempted to 'rotate' the pinwheel and to affect a Crooke's radiometer. On the evening of the first night, the patient called us around 22:00 h and reported that she 'felt' something was about to happen. Two of the authors took the equipment to her hotel room. The electrode cap was applied and EEG measurements were taken for about 40 minutes. The experimenter (K.S.) observed clear pinwheel rotations on several occasions. The computer recordings were time-stamped during these periods for later comparisons between non-rotation and rotation periods.

Background geomagnetic intensities within the horizontal (X, Y) and vertical (Z) dimensions are routinely recorded in our laboratory every 1 minute over 24 hours per day on a separate laptop computer from a MEDA FVM-400 fluxgate magnetometer. We have been studying the relationship between local ground photon emissions and geomagnetic activity in order to understand transient geomagnetic anomalies (Persinger & Dotta, 2011). Daily means for the most disturbed component are correlated more than 0.9 with values from other sites in North America as well as the global average. The values were correlated with her behavior while visiting the laboratory.

When she returned to her hometown, she recorded the day and time (to the nearest minute) for a total of 33 different episodes of phenomena over a 2-week period. To correlate these data with geomagnetic activity data were obtained (for convenience) from a Danish magnetometer (http://www.sgo.fi/Data/ Magnetometer/ magArchive.php) site. Times of Ms. S's reported phenomena were considered key minutes while 33 'reference' minutes at least 1 hour before or after the occurrence of a phenomenon were employed as comparisons. A MANOVA epoch analysis was completed with the geomagnetic components for each minute for 30 minutes before and for 30 minutes after the key minutes.

During Ms. S's visit to the clinical laboratory, her reports of sudden increases of the phenomena occurred concomitantly with increases in geomagnetic activity as measured both by global data bases and our magnetometer. To test the sensitivity in a controlled, experimental sitting, the patient volunteered to sit within the acoustic chamber while a simulated geomagnetic storm produced by amplitude-modulating a 7-Hz square wave magnetic field that increased and decreased in successive steps between 0 and 50 nT over a period of 6 minutes (Mulligan & Persinger, 2011). This imitation of an average sudden geomagnetic impulse was created between two 1.25 × 1.25-m coils placed on each side of the comfortable armchair in which she was sitting. Each coil was composed of 72 turns of 30-gauge (AWG) wire wrapped around the perimeter of an aluminum rack to form a band 13 cm wide. She was not aware of the onset of the field whose structure was controlled by computer software from a computer outside of the closed chamber. At the time of the study with Ms. S we were employing this procedure in another experiment to study experimentally what components of geomagnetic activity contribute to the observed correlational shifts in power over the right hemisphere (Mulligan et al., 2010; Mulligan & Persinger, 2011).

Examination of classic cases of individuals associated with the poltergeist phenomenon indicates they display symptoms congruent with right orbital frontal as well as right temporal lobe anomalies (Roll, 1986; Roll & Storey, 2004). In our clinical experience, individuals with right orbital frontal injuries either have clear difficulties completing the Conditioned Spatial Association Task (CSAT) or exhibit a 'catastrophic response', defined as facial flushing and sudden anger, when they attempt to complete it. The CSAT requires the person to associate one of six numbers on separate cards in front of her with a specific light contained within an array of six identical lights by listening to 'yes' or 'no' feedback for each successful number selection ('guess'). QEEGs were completed before and after the CSAT as well as while Ms. S. saw specific colors around different individuals which was intermittent.

We did not complete a thorough neuropsychological assessment on Ms. S. The results of an abbreviated (168) Minnesota Multiphasic Personality revealed a normal profile. For over a year after the measurements Ms. S has sent us weekly reports of her experiences and perceptions. Her profile did not change and her social interactions and friendships remained constant.

RESULTS

The most conspicuous feature of the patient's EEG was the continuous anomalous activity over the right temporal lobe (T4). The spectral frequencies were between 20 and 25 Hz (see Figure 1). The peak-to-peak amplitude of this pattern was about three times the magnitude of all other channels. During the last 30 years we have assessed

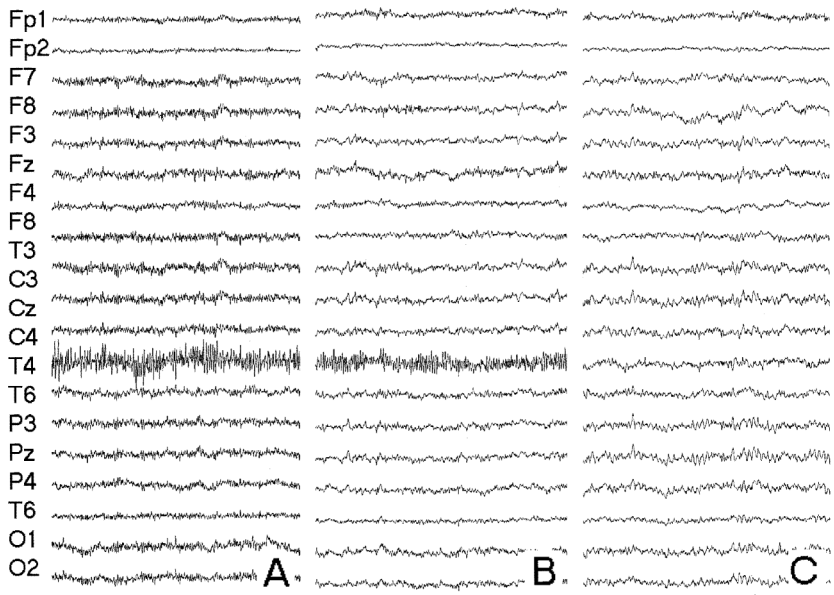

Figure 1. Sample EEG activity over 19 channels displayed by Ms. S. Note the persistent high amplitude (100 μV) over the right temporal lobe compared to all other lobes (about 20 μV). (A and B) are separated by one day. (C) Shows the attenuation of the T4 anomaly after the doors of an acoustic chamber were closed.

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approximately 1,000 patients who had sustained closed head injuries as well as comparable numbers of normal university students recruited for various experiments. We have never measured the type of persistent anomaly displayed by Ms. S.

The right temporal lobe anomaly attenuated within about 20 seconds to 1 minute after the doors to the acoustic chamber were closed. In addition to providing above average silence, this procedure reduces the static background geomagnetic field from 50,000 nT to about half that value. When the T4 anomaly was not distinguishable and she was sitting within the closed-door chamber she reported experiences as if she was 'missing' something that was similar to a 'craving'.

sLORETA of the chronic temporal lobe anomaly displayed by the EEG showed decreased theta activity within the posterior cingulate bilaterally and verified an increase power within the right temporal region for frequencies above 16.5 Hz. The most powerful effect was a marked increase in power within the 30-Hz range within the right insular region (Figure 2). The power within these regions, particularly the right insula, diminished

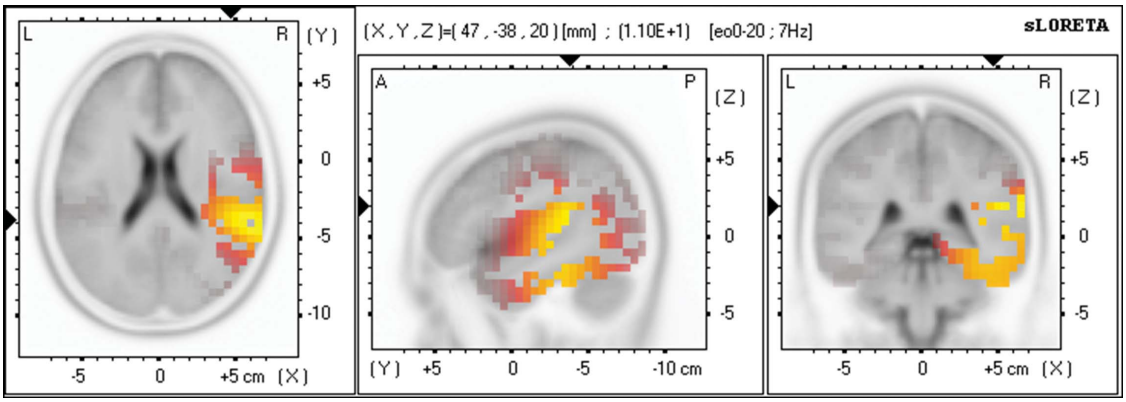

Figure 2. sLORETA images showing the inferred areas of increased activity within the cerebrum. Note the increased activity diffusely within the right temporal and insular regions. [To view this figure in color, please visit the online version of this Journal.]

significantly when the doors to the acoustic chamber were closed.

When she was asked, while sitting in the dark, to focus her thoughts to rotate the pinwheel or to focus 'light', there were no significant changes, $F(1, 445) = 1.77$; $p = .10$, in the output of photon energies from the right side of her head when she was asked to focus the light compared to when she was relaxing. However there were spontaneous increases (1–10 second durations) in photon emission within the 2.5×10^{-11} W/m^2 range. These increases in photon output were concurrent with the unilateral appearance of a specific and anomalous microstate that appeared over the right temporal lobe.

When Ms. S. reported the spinning of the pinwheel in normal lighting the steady potential values ranged within the normal range between 10 and 12 mV. Following the reported movement (after the effort) the potential difference increased transiently for about 100 seconds to 25 mV. When applying her left hand in the same manner as before to produce the pinwheel motion, there was no movement in the Crooke's radiometer.

Comparisons of the sLORETA for periods when the pinwheel rotated vs. did not (when she 'felt' the phenomena about to occur in her hotel room) revealed a marked increase in power within the delta (1–4 Hz) range within the medial frontal gyrus (primarily along the left hemisphere) and increased power within the beta and gamma ranges within the medial frontal, cingulate gyrus, and subcallosal region (Figure 3). During this period she heard her imaginary friends very clearly. During the 10–20 seconds when the pinwheel was seen to rotate by one of the experimenters, coherence analyses indicated the greatest interhemispheric intercalation between T5 and T6. There was a statistically significant increase by almost a factor of 2 in coherence within the theta, $F(1, 9) = 10.53$, $p = .01$; eta$^2 = 0.78$, band during the periods of rotation compared to the periods when there was no obvious rotation. Further analysis indicated that increase was primarily within the 6–7-Hz range.

Although the patient was not aware of the onset of the 0–50-nT, 7-Hz amplitude-modulated magnetic field that had been designed to simulate an activated geomagnetic condition, she reported a

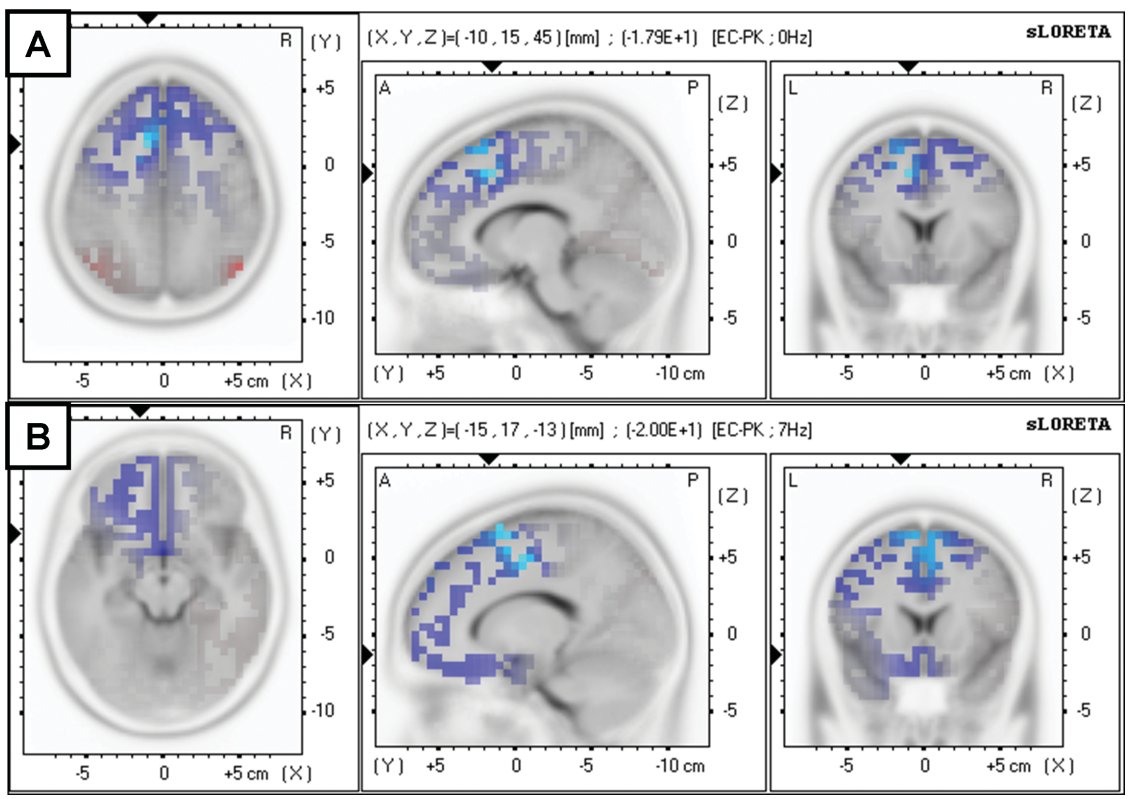

Figure 3. sLORETA images of the increased activity within the medial frontal, anterior cingulate and subcallosal region during 'concentration' when the pinwheel rotated. This was not evident when 'concentration' occurred and there was no rotation. [To view this figure in color, please visit the online version of this Journal.]

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profound 'sudden sadness' and began to cry with feelings similar to those following the occurrence of the phenomena. Her 'discomfort' began within about 2 seconds after the field was activated and escalated during the 6 minutes of exposure. The simultaneously measured EEG revealed a striking change in Ms. S's dominant EEG topography.

The continuous right temporal lobe anomaly, we had measured during her baseline, appeared shortly after the onset of the field (as well as her reported distress). The anomaly was associated with marked synchronization of 2 Hz between all channels. There were also two peaks at 7.8 and 10.7 Hz except over channels F8 and T4. These two discrepant channels displayed a singular peak at 8.8 Hz. Because of the intensity by which she responded, we did not present the field sequence for a second time.

Ms. S. successfully completed the CSAT and there was no evidence of a catastrophic response which is often considered an indicator of frank damage to the right orbitofrontal region. Comparison of sLORETA profiles before and after the task revealed no significant differences. She reported and sketched different 'glows of colour' around different people that was considered discriminatory for each person. The colors which included pink, green, blue, brown, and yellow were perceived more clearly in her peripheral vision. However, there was no reliable sLORETA images associated with her reports and the different colors.

During her 2 days in the laboratory, global geomagnetic activity was unstable. During the first evening before testing began she had reported tapping sounds in the location (to her left) of the window in her hotel bedroom, the presence of 'entities', and unusual lights around objects. *Post hoc* examination of the approximate times were within 10 minutes of increases (at a rate of greater than about 10–20 nT/10 minutes) in the strength of the vertical component of the local geomagnetic field. A K-6 level geomagnetic storm was occurring at the time.

Subsequent epoch analyses of her diary entries to the nearest minute over a 14-day period after she returned home and the changes in geomagnetic intensity from the Danish magnetometer site showed a significant increase in the strength of the vertical (Z) component of the geomagnetic field that started approximately 10 minutes preceding her experience of phenomena. MANOVA revealed a statistically significant, $F(120, 6960) = 1.48$, $p < .002$, interaction between magnetic components

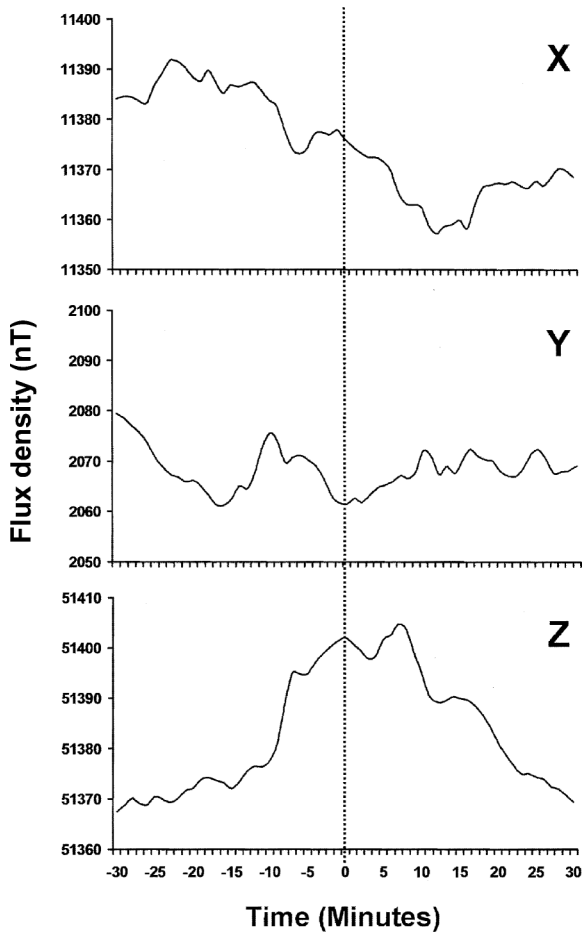

Figure 4. Significant increases in the vertical (Z) component of the magnetic field but not the horizontal (X, Y) components from a Danish magnetometer station as a function of the minutes before and after the occurrence of the 33 different events reported over 2 weeks in Ms. S.'s home.

(X, Y, Z) and the occurrence or non-occurrence (reference time) of phenomena. *Post hoc* analyses revealed the effect was due to the increase intensity of the vertical field component by about 30 nT during the 10-minute period preceding experiences of phenomena (Figure 4).

DISCUSSION

The cerebral electrophysiological profile of this patient reiterates the frequent clinical observation that extreme and anomalous behaviours are associated with conspicuous and anomalous differences in brain function. In this instance the anomaly consisted of persistent high amplitude (100 μV compared to the average 20 μV) 20–25-Hz pattern over the right (primarily) temporal lobe. Inferences

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of changes within deep structures by sLORETA showed regional increased power within the 30-Hz band, compared to norms, within the right insula and slower beta activity within the right temporal lobe and posterior cingulate.

Unusual patterns of activity within the right hemisphere is consistent with the experience of sensed presences of 'sentient beings' reported by patients who have sustained closed head injuries (Persinger, 1993a, 1993b) as well as normal volunteers when exposed to weak, physiologically patterned magnetic fields designed to evoke these experiences (Booth et al., 2005; Booth & Persinger, 2009). Although there were small increases in photon emissions from the right side of her head that was associated with the occurrence of a specific microstate which was dominated by a right temporal lobe polarity, the absolute magnitude of the photon emission was within the range of normal people engaging in visual imagery (Dotta, Saroka, & Persinger, 2011) within the same setting. Ms. S's subjective reports that the rotation of the pinwheel could be modulated as a function of the loudness of music to which she listened through ear pieces as well as the spontaneous sounds associated with the phenomena implicate the classic role of the temporal lobes.

In our opinion, from the perspective of treatment, the most important observation was the increased power in the delta range within the medial frontal and anterior cingulate region as inferred by sLORETA when the pinwheel was moving as verified by an external observer in her vicinity. Although increased activity in the latter region, particular the right anterior insula is associated with disembodied hallucinatory voices (Craig, 2009; Sommer et al., 2008) and auditory hallucinations (Szechtman, Woody, Bowers, & Nahmias, 1998), which Ms. S experienced and attributed to her invisible friends, the involvement of the prefrontal region suggests organization, intent, and an awareness that some process was occurring. This was reflected in her reports that 'something' was about to happen in a manner similar to a preictal state.

The antecedents of these experiences are likely to have occurred within the right temporal lobe for two reasons. First, there was a marked increased coherence within the 6–7-Hz band between the two regions in the temporal lobes, one of which was near the source of the chronic anomaly. Secondly, she responded with intense sadness and emotion, very similar to what happens after the 'spontaneous' display of these experiences, when she was exposed without her knowledge to a 7-Hz amplitude modulated experimental magnetic field with intensities similar to those associated with increased geomagnetic activity. Her profile was similar to people who are easily entrainment by weak applied, physiologically patterned magnetic fields (Persinger et al., 2009). In fact her presentation clinically was quintessentially representative of Bear's (1979) temporal lobe syndrome of sensory-limbic hyperconectionism that is frequently seen in subclinical (Persinger & Makarec, 1993) and clinical (Bear & Fedio, 1977) complex partial epileptic patients with foci within right temporal lobe (Bancaud, Brunet-Bourgin, Chauvel, & Halgren, 1994).

In our experience, many patients with closed head injuries have reported sensitivity to weak magnetic fields. We have shown this effect with single cases (Persinger et al., 2009). Subsequent analyses of Ms. S.'s reports for weeks after she left the laboratory showed that the report of the unusual experiences occurred during the 10-minute period after increases greater than approximately 25 nT intensity in geomagnetic activity. A similar threshold has been reported for report of bereavement apparitions (Persinger, 1988) and for vestibular experiences during partial sensory deprivation in the normal population (Persinger & Richards, 1995).

Our (Saroka & Persinger, 2011) experiments with other forms of cerebrally applied magnetic fields may help explain why the rotation of the pinwheel diminished when she listened through earphones to music. Many of these small solenoids (of the earphones) applied upon the ears, which are immediately adjacent to the temporal lobes, can generate magnetic field energy levels that are equivalent to the mechanical patterns that generate sound. Whether or not this strategy could be used therapeutically to control unwanted experiences remains to be established. We have counseled patients, who experience terrifying nocturnal-sensed presences subsequent to closed head injuries, to quickly activate an acoustic source and to listen to music containing lyrics. This simple temporal lobe stimulation eliminates the experience of a sensed presence.

From one perspective (Persinger, Saroka, Koren, & St-Pierre, 2010) there is no requirement to verify or argue the merits of the veridicality of the phenomena, even the movement of the pin wheel which was seen by members of our group. Given: (1) the similarities of frequencies between the 'beats' of the sounds that occurred when she was physiologically upset and/or there was increased geomagnetic

activity, (2) the right temporoinsular dominance of the anomalous EEG activity, and (3) the frequent association between auditory hallucinations, visual auras, sensed presences and right temporal lobe transients, patients who show this pattern and who are exhibiting distress about them might be treated by low dosages of anticonvulsant pharmacology as well as by restructuring (Persinger, 1993a) their cognitive beliefs about the origin of the phenomena.

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